

Exhibit D – Need

Commonwealth of Massachusetts

Ph2ExhibitDNeedMA.pdf

Phase 2 Factor 2: Need/Extent of the Problem

DropBox: https://www.dropbox.com/sh/zoa761j595fqc41/AAD4oJ1B-hc_eq21pSB-UF0_a?dl=0

a. Unmet Recovery Need and Target Geography

Massachusetts Target Area. All of Massachusetts (MA) is a Target Area for resiliency under this application. Each county was impacted by two to five of the six federally declared disasters that occurred in MA between 2011 and 2013. These disasters resulted in over \$280 million in damages (MEMA 2015.pdf).

1) FEMA DR- 1959: Severe Winter Storm of January 11-12, 2011 (Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk and Suffolk Counties): High winds brought down trees and power lines, causing over 227,087 power outages statewide. **2) FEMA Disaster 1994: Tornado of June 1, 2011** (Hampden and Worcester Counties): Three tornadoes and thunderstorms impacted western and central MA, including power losses, damage to trees and vegetation, and uprooted trees/debris. **3) FEMA Disaster 4028: Tropical Storm Irene of August 27 – 29, 2011** (Barnstable, Berkshire, Bristol, Dukes, Franklin, Hampden, Hampshire, Norfolk and Plymouth Counties): A Tropical Hurricane crossed MA, resulting in uprooted trees; damage to vegetation; extensive riverine flooding and erosion, damage to infrastructure, homes and businesses; and loss of power. **4) FEMA Disaster 4051: Severe Winter Storm of October 29-30, 2011** (Berkshire, Franklin, Hampshire, Hampden, Middlesex and Worcester Counties): A winter storm of up to 32” of heavy wet snow and gusts up to 70 mph caused tree and power line damage. In some cases weeks, power outages took weeks to restore. Nearly 700,000 residences and businesses lost power. **5) FEMA Disaster 4097: Hurricane Sandy of October 27 – November 8, 2012** (Barnstable, Bristol, Dukes, Nantucket, Plymouth and Suffolk Counties): Coastal MA was affected by a Category 1 hurricane, which resulted in storm surge, rain and tropical storm force winds. Gusts of 65-80 mph resulted in power losses and evacuations. **6) FEMA DR-4110: Winter Storm Nemo of February 8-10, 2013** (all counties in MA): A severe winter storm with high winds, storm surge and 2’ of heavy wet snow caused power loss for 650,000.

While most of MA’s unmet recovery need is in the western region of the state, all of MA needs to prepare for the effects of climate change and become resilient. The MA Team has identified an unmet

recovery need for more trees statewide, but especially in urban areas where the impacts of stormwater runoff and urban heat island effect are greatest. The loss of tree canopy due to recent disasters means that, with increasing precipitation and rising temperatures due to climate change (MA_Climate_Change_Adaptation_Report.pdf), these urban communities, home to vulnerable low income populations, will feel the effects of urban flooding and urban heat island even more intensely in the future. The MA Team has also identified the unmet recovery need for more resilient and reliable heat and energy during disasters, especially at critical facilities such as police stations and hospitals which must remain open during disasters; at municipal buildings, such as schools that can serve as emergency shelters during storms and heat waves; and in the housing of low and moderate income persons who are less able to seek alternative shelter during disasters. MA proposes to devote significant resources to enhancing the resilience throughout the state through planting trees and providing resilient and reliable power and heat (Exhibit F).

MID-URN Target Areas. Target Areas for HUD funding (Exhibit B) are the City of Springfield in Hampden County; the Deerfield River Subwatershed, the contiguous area of the communities of Rowe, Monroe, Hawley, Heath, Charlemont, Buckland, Shelburne, Colrain, and part of Greenfield in Franklin County; and the Town of Williamstown in Berkshire County (Attachment E: Figures B-1, B-7 and B-9). Disasters causing most damage to housing, the environment, and infrastructure were the June 1, 2011 tornadoes and the October 29-30, 2011 snowstorm in Springfield, and the August 27-29, 2011 Tropical Storm Irene in the Deerfield River watershed and Williamstown. Other qualifying events are listed above.

Updated MID-URN Target Areas. Through phone calls, emails, and meetings, the MA Team has been in close contact with affected stakeholders, communities and regional planning agencies to document unmet recovery needs. The Deerfield River Subwatershed Target Area was created by expanding and combining the Phase 1-approved Target Areas of Charlemont and the Buckland portion of Shelburne Falls, and adding a damaged bridge and culvert/sewer in Greenfield to the damage and unmet recovery needs. Because the previously demonstrated unmet recovery need at Trout Brook/Route 2 in Charlemont straddles two census blocks, both blocks were included in Phase 2. They are the Phase 1-qualified Charlemont Target

Area (Census Block #0110401001), which also includes Rowe and Monroe, and the abutting Census Block #0110401004, which includes Hawley and the remainder of Charlemont. The Phase 1-qualified unmet recovery need for the Buckland side of Shelburne Falls was due to bank erosion at the Shelburne Falls Fire District's wells on the North River in Colrain, which is threatening the water supply of Shelburne Falls, in Buckland and Shelburne. This erosion has also created an unmet recovery need related to environmental degradation in the North River (between Census Blocks # 0110401002 and 0110401003), affecting Colrain and Heath on either side of the river. Unmet recovery need of housing in Williamstown was documented by Berkshire Regional Planning Commission staff during a windshield survey in August 2015 (Exhibit B).

Springfield Target Area. On June 1, 2011, four tornadoes cut a six-mile swath through Springfield, mostly affecting five low income neighborhoods and resulted in a five-day State of Emergency (http://photos.masslive.com/masslivecom_photo_essays/2011/06/mapping_the_path_of_tornadoes.html; http://www.springfield-ma.gov/cos/fileadmin/reports/HMP_for_Public_Review_and_Comment.pdf). The tornadoes caused widespread power outages and one fatality in Springfield. Hundreds of roofs were torn off of homes and commercial buildings, and rental units for over 300 residents were lost. The Brookings Elementary School, Dryden Elementary School, and Cathedral High School, all in Springfield, were closed due to heavy damage (MEMA_DR-1994_2011.pdf). The Springfield Fire Department received 15,070 emergency calls and responded to 15,953 emergencies. For several weeks following the tornadoes, the city's Office of Emergency Preparedness facilitated meetings between the City's leadership, local utility companies, the Pioneer Valley Red Cross, the Salvation Army and other critical businesses (http://www.springfield-ma.gov/cos/fileadmin/reports/HMP_for_Public_Review_and_Comment.pdf.)

The tornadoes de-vegetated portions of Springfield; snowstorms from other disasters decimated additional vegetation. Almost 10,000 acres of woodlands, including 7,500 mature trees, were destroyed in the tornadoes (<http://treesatrisk.com/tornado-season-remembering-1953-and-2011/>). Springfield's infrastructure was also affected by the tornadoes and the October 29-30, 2011 snowstorm. The city paid \$750,000 to repair roads, sidewalks, and significant sections of roads and sidewalk damaged by uprooted

trees (http://www.masslive.com/news/index.ssf/2011/07/springfield_to_hire_firm_to_repair_tornado-damaged_roads_and_sidewalks.html). Unmet recovery need includes \$6,375,975 in damage to the flood control drainage system on Riverside Road and in debris removal and repairs to roads, curbing and sidewalk damaged from overturned trees from the October 29-30, 2011 snowstorm. It includes damage to Van Horn Dam and Watershops Pond, and debris removal and drainage/culvert repairs (\$2,620,000) (Exhibit B).

The City estimates that 30% of its trees were lost during the tornados; this is an unmet recovery need. This loss, combined with the high amount of impervious cover and the undersized drainage system in Springfield, has increased the potential of both urban flooding from stormwater and of the number and frequency of combined sewer overflows (CSOs) into the Connecticut River. The city is experiencing more intense heat island effect as a result of the loss of trees. In the East Forest Park area of Springfield, where street-side tree canopy cover was stripped to 1%, the U.S. Forest Service estimated that mean morning and afternoon temperatures increased between 1-2°C, compared to an unaffected neighborhood with 44% canopy cover (<http://www.unri.org/wsb4713307301/wp-content/uploads/2011/07/tornado-climate-report-2-reduced-size.pdf>). The government, residents and business owners are likely experiencing more expenses related to both heating and cooling because of the lost trees. There are several unmet recovery needs related to the loss of trees. First, there needs to be sufficient tree stock to provide better management of urban runoff, urban heat island, and heating and cooling costs. Even with the planting of over 14,000 trees, as proposed in combination by Springfield and the Commonwealth, it will take many years for the replacement trees to provide stormwater management and cooling services to the fullest. Therefore, another unmet need is to alleviate urban flooding. Springfield also needs stormwater tree box filters, designed to increase the uptake of stormwater per unit. In September 2015, NOAA issued Atlas 14, Volume 10 (<http://hdsc.nws.noaa.gov/hdsc/pfds/>), which updates rainfall frequencies, last updated in the 1961 Technical Paper (TP)-40 (http://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf). The “100-year storm” or that storm having a 1% chance of occurring in a year has increased in magnitude from 6.5” to 7.48” and that does not take into consideration the effects of future climate change.

To prevent damage to the city's infrastructure and enhance resilience, the aged culverts in Springfield need to be re-sized and replaced to accommodate updated or future rainfall frequencies. Pipelines carrying combined sewage from the city to the regional wastewater treatment plant need to be resized to account for larger combined sewage flows. Stormwater needs to be removed from the combined system, where possible, to reduce the potential for CSO activations and repairs are needed to reduce sanitary sewer overflows associated with intense precipitation. An unmet recovery need is to decrease the city's impervious cover. Replacing pavement and other hard surfaces with natural systems of green infrastructure and redirecting rainwater into the ground will help reduce urban flooding and CSOs. Trees and green infrastructure, like tree box filters, will also provide needed relief from increasing temperatures from the loss of the trees and climate change. Another unmet recovery need is that wastewater facilities in Springfield need to be made resilient against the type of flooding that occurred upstream at the Greenfield Wastewater Treatment Plant. There are seven flood-control pump stations serving Springfield that are located in the floodplain and are 70-75 years old. Most of their equipment and electrical systems are original and have not been flood-proofed. In the event of a hurricane or large storm event with substantial flooding, these pump stations could be flooded and fail, resulting in the discharge of large volumes of untreated CSOs to the Connecticut River. These pump stations need to be made resilient against inundation during heavy precipitation.

In Springfield, 615 residential units were damaged and condemned as a result of the tornadoes. While many homes have subsequently been repaired, residential rental units have not been rebuilt as quickly. 170 residential rental units have yet to be rebuilt, including 60 units of public and subsidized housing. Nearly all (97%) of the missing residential rental units are in the City's most economically distressed neighborhoods and a lot of these were in 1-4 unit buildings. These buildings have been cleared, leaving vacant lots throughout the neighborhoods that are overgrown and used for dumping. Unmet recovery need is \$4,681,145 for the loss of 14 affordable housing units owned by the Springfield Housing Authority and 26 owned by Hill Homes Cooperative (Exhibit B). Through the ReBuild Springfield planning process, the community identified a goal of developing a process for transforming vacant lots and structures into community assets.

The devastating effects of the tornadoes compounded the years of urban sprawl and disinvestment, worsening the city's blighted areas. As the city rebuilds, its low and middle income populations need shade trees and reliable, resilient and affordable energy and power that can withstand the effects of future storms.

Deerfield River Subwatershed Target Area (see *Exhibit B for Census Blocks*). Up to 10 inches of rain fell in this Target Area during Tropical Storm Irene, causing record flood stages throughout northwestern MA, including the Deerfield River (http://pubs.usgs.gov/ds/775/pdf/ds775_report_508.pdf), a tributary of the Connecticut. Torrential rains caused miles of impassable roads and culvert damage; damaged hundreds of buildings; uprooted trees and vegetation; and dislodged demolition debris, roadways, and bridges, washing them downstream. The rapidly rising flood waters inundated water and wastewater facilities and dislodged propane and gasoline tanks, contaminating properties, homes and the rivers. Trees and power lines were lost, resulting in a loss of power for several days to many residents. (Deerfield_Irene_Photos_2011.pdf) Effects of the storm stretched from Canada, through VT, NH, MA and CT. Statewide, 670,000 utility customers lost power. Nearly a week after the storm drenched New England, the Connecticut River was spewing muddy sediment into Long Island Sound (<http://earthobservatory.nasa.gov/IOTD/view.php?id=52059>). The State Geologist estimated that 1.2 metric tons of sediment were discharged by the Deerfield River, producing as much as 40% of the total sediment observed in the lower Connecticut River (<https://mgs.geo.umass.edu/biblio/landslides-tropical-storm-irene-deerfield-watershed-western-massachusetts>).

Four landslides of sediment, trees, rocks and debris along the Cold River within the Deerfield River watershed caused a 6-mile stretch of Route 2 from Charlemont to Florida to close for over 3 months, disrupting a major connector to the metro-Boston area. Charlemont also experienced damage to culverts and destabilization of the surrounding area. High flows in the North River (tributary to the Deerfield River) scoured the banks, damaged the water supply wells of Shelburne Falls, and breached a privately-owned dam. Nearly two years, later, fallen trees were still threatening a town-owned park and the Hawlemont Regional

Elementary School in Charlemont by re-directing Rice Brook (<http://www.charlemont-ma.us/sites/default/files/minutes/selmin062413.pdf>).

While MassDOT repaired the culvert at Trout Brook in Charlemont immediately after Tropical Storm Irene, it was designed using rainfall frequencies from TP-40. An unmet recovery need is to replace the culvert at Trout Brook with one that has been properly sized; cost is \$1,167,000. To increase the river's resiliency against intense streamflows, restoration of the streambed at Trout Brook and Route 2 is also needed; cost is \$400,910. Also in Charlemont, the Sewer District and the town's municipal complex (with the Highway Garage, Fire Department, and Police Department) are on three parcels abutting the Deerfield River. During Tropical Storm Irene, both the Sewer District and town facilities were significantly flooded. The Town of Charlemont's 2014 Local Multi-Hazard Mitigation Plan stated, "Note should also be taken of the fact that the town's wastewater treatment facility lies within the floodplain. There is potential for release of hazardous waste from this facility during a flood" (http://www.charlemont-ma.us/sites/default/files/Attachments/charlemont_hazmit_finalreviewdraft_7-18-2014-1.pdf). Listed as "significant structures within or adjacent to the floodplain in Charlemont" (p. 50 of the Hazard Mitigation Plan), the wastewater treatment facility has a total building value in the floodplain of \$700,000, the Fire Station has a total building value in the floodplain of \$177,000 and the Highway Department has a total building value in the floodplain of \$899,000. The facilities are vulnerable to the impacts of excessive precipitation, heavy snow, hurricane winds, and dam failure associated with Bear Swamp Hydroelectric Dam, which is owned by Brookfield Renewable Energy upstream from Charlemont. An unmet recovery need is to conduct a feasibility study and identify alternative locations and ways to harden structures within the municipal complex and the treatment plant.

Riverine flooding from Tropical Storm Irene caused erosion of banks of the North River in Colrain (a tributary to the Deerfield) near the Shelburne Falls Fire District's water supply wells, which supply water to 2,200 residents of Shelburne Falls, situated in Shelburne and Buckland, and to 50 residents of Colrain. During Tropical Storm Irene, flooding damaged the electrical system to the wells and excessive sediment

washed over fields, roads, and into buildings; the wells were flooded and off-line for 7 days following the storm. The banks of the North River need to be restored and strengthened. The water supply is vulnerable to future flooding and will be a complete loss unless the river bank is stabilized. Unmet recovery need to repair the banks of the North River is \$460,000. The wellheads need to be raised above the floodplain and the electrical system needs to be moved out of the floodplain; unmet recovery needs for these resiliency measures are \$10,000 to raise the well heads and \$219,000 to move the electrical system..

Destabilized banks have caused environmental degradation of the North River in Colrain and throughout the Deerfield River watershed. The riverine system continues to be at risk of losing massive amounts of sediment, causing water quality impairments, and critical infrastructure is at risk throughout the Target Area. An unmet recovery need in the Target Area is improvements to the grey infrastructure to accommodate larger and more frequent storm events and the natural tendencies of the river's fluvial geomorphology, or be at risk of being destroyed again in the next massive hurricane. Improvements in the grey infrastructure must be accompanied by improvements in green infrastructure, another unmet recovery need. Installations of green infrastructure in the river and on the banks will help to modulate high flows from severe storm events, protect critical infrastructure from flooding and fluvial erosion, and prevent sedimentation of the river.

Flooding from the Green River (another tributary to the Deerfield) impacted the Colrain Street Bridge area and damaged the Green River Dam, the Leyden Glen Dam, the Eunice Williams Covered Bridge, and Eunice Williams Drive, and severed an 8" sewer line in Greenfield (http://www.townofgreenfield.org/Pages/GreenfieldMA_Planning/HazMitPlan.PDF). Hundreds of residents were evacuated in Greenfield and houses and businesses were filled with mud and silt. The Greenfield Department of Public Works estimated infrastructure damage of \$12.5M as of October 4, 2011 (http://www.townofgreenfield.org/Pages/GreenfieldMA_Planning/HazMitPlan.PDF). Damage occurred on Glen Road, an access route to the Town's water supply reservoir. Greenfield's wastewater treatment plant, located at the confluence of the Green and Deerfield Rivers, was flooded with 18 feet of water. Costs to

repair the plant exceeded \$650,000 (Greenfield WWTP Damage.pdf). Trees, including stormwater tree boxes, are an unmet recovery need in Greenfield. More trees in Greenfield would help to manage and treat stormwater flows, which are expected to increase as the climate changes, as well as help to reduce the heat island effect.

Tropical Storm Irene caused the Maple Brook Drainage Culvert in Greenfield to heave upward, disturbing drainage and sewer lines. Since then, infiltration and inflow into the sanitary sewer system have increased to 5 to 8 million gal/day, and there is surcharging of sewer and drainage manholes at various locations across the town. During heavy rain, untreated wastewater discharges directly to the Green River through a flow regulating chamber overflow. The city has hired an engineer to design a new sewer main to run outside of the drain line. The estimated cost is \$2,134,000 (AECOM_2015.pdf, Greenfield Maple Brook.pdf). Greenfield has \$134,000 for this project; \$2,000,000 is an unmet recovery need. Also in Greenfield, Tropical Storm Irene compromised the Nash's Mill Bridge by scouring and moving the bridge abutments (GreenfieldNashsMillBrdg.pdf). After the storm, the bridge was deemed unsafe for normal traffic. Currently, it is restricted to one lane and has a weight limit of 12 tons. Fire trucks and buses are prohibited from use, causing a significant safety concern for the fire department and increasing transportation costs for the school department. The bridge needs to be built at a higher elevation and the abutments need to be moved upland, out of the river. The project was recently added to the State DOT's project list; however, funding will not be available for 8 to 10 years so the unmet recovery need is \$3,000,000 for construction. Total unmet recovery need for infrastructure and environment in the Deerfield River Subwatershed is \$7,246,910.

Stormwater runoff increases with development of impervious surfaces, and is predicted to increase further with more intense precipitation of climate change. To ensure resiliency, the Target Area needs to maintain, and improve the health and resilience of, its original, natural green infrastructure – the forest. Unlike urban Springfield, which needs more green infrastructure and reduction of impervious surfaces to ensure that stormwater is captured and directed into the ground, the Deerfield River Subwatershed Target Area already has a natural system in place that, if enhanced, could provide more effective protection against

flooding and water quality impacts during hurricanes and due to climate change. An unmet recovery need of the Target Area is to put in place better forestry practices to ensure that the currently neglected forest becomes more diverse in species and age. A more diverse forest will prove to be more resilient against specific types of pest infestations and storms. If one species or age class is decimated, the others are more likely to survive. A healthy forest will encourage uptake of water from storms and capture of nutrients and other pollutants that wash over the watershed and enter the Deerfield River as nonpoint source pollution. Another unmet recovery need is that the owners of these forests – most of them are privately owned – need improved economic conditions and need an incentive to avoid converting their forests, which provide tremendous ecosystem services, into impervious surfaces. To meet these needs, a higher value must be placed on the wood products from the area and forest owners need an incentive to increase forestry using healthy, sustainable practices.

Tropical Storm Irene left many homes and public buildings without power for days. A year after Tropical Storm Irene, electric utility National Grid reflected on lessons learned from the storm and determined that it needed to control damage from trees by "collaborating with local communities on aggressive tree trimming to help limit outages during future weather events" (<http://patch.com/massachusetts/attleboro/national-grid-says-lessons-learned-from-irene>). The Target Area has the unmet recovery need for reliable and renewable energy and heat so that it can withstand long periods without services. Heating fuel in the Deerfield River Subwatershed Target Area is limited to oil and propane. An unmet recovery need is another option for heating fuel that is more local and less susceptible to delivery and service interruptions resulting from storm damages to critical road infrastructure, such as Route 2. This Target Area also has the unmet need of a program to manage trees that threaten electrical lines and property.

Williamstown Target Area. In Williamstown, 191 homes at the Spruces Mobile Home Park were damaged or destroyed by flood waters along the Hoosic River, rendering them permanently uninhabitable and displacing 270 residents. This mobile park was a 55 years and older community for low income families, most of whom did not have insurance on their homes. At a December 2013 special town meeting in

Williamstown, residents overwhelmingly voted to take ownership of the park and place a conservation restriction on the 116-acre parcel. The Selectmen signed a notice of discontinuance stating the flood-prone Spruces Mobile Home Park will close as of February 29, 2016. The town hired a Relocation Agent to help residents find new housing; spending at least 10 hours with each household to assess their cases (http://www.berkshireagle.com/news/ci_25248221/closing-date-williamstown-s-spruces-mobile-home). The newly constructed Highland Woods will be a 40-unit community of one- and two-bedroom apartments ready for occupancy in early 2016. This housing will be available to those with incomes up to 60% of Area Medium Income. This is a start, but there still remains an unmet recovery need for affordable housing in Williamstown of 151 units of \$49,055,000. An additional 46 units of affordable housing are planned at 330 Cole Avenue, a brownfield in need of cleanup before housing construction can begin.

b. Resilience Needs Within Recovery Needs

b.1 Extent to Which Resilience Action Could Have Limited Effects.

Example #1. Greenfield Water Pollution Control Plant, which was severely flooded during Tropical Storm Irene, thereafter flood-proofed its facility to protect against floods at the 100-year flood elevation. The town invested \$650,823.06 to remove all equipment from the basement to the first floor and installed two flood protection doors to give the facility an elevation of 144.3 feet; the doors cost \$107,246. These measures protect wastewater treatment services for the 17,456 residents of the city. Had they been implemented before Tropical Storm Irene, the plant would have avoided \$650,000 in damages and the resiliency measures would have paid for themselves (Greenfield WWTP Damage.pdf)

Example #2. Damage from Tropical Storm Irene to a 6-mile stretch of Route 2 from Florida (outside of the Target Area) to Charlemont included debris flows, four landslides, fluvial erosion, and undercutting of infrastructure, costing \$23M (MassDOT_Irene_Repairs.pdf) and resulted in a 3.5 month shut-down of that stretch of road, causing disruption to people's travel. In 2013, the MA State Geologist developed a series of slope stability maps (including one for the Deerfield River Subwatershed Target Area) and an accompanying report (Slope_Stability_Map_MA_Report.pdf and LandslideMap.pdf). According to his report, landslides in

MA occur with regular frequency and result in annual costs to MassDOT of \$1M for cleanup and \$2M for preventative measures. The maps show the locations of potential landslide hazards in MA and provide the public, local government and local and state emergency management agencies with locations of areas where slope movements have occurred or may possibly occur in the future under the right conditions of prolonged antecedent moisture and high-intensity rainfall. This information will be useful to MassDOT and local highway departments as they plan upgrades and improvements to infrastructure and facilities that may be at risk. The cost to develop the maps and study was \$64,261; if these tools are used to identify priority areas for protection and improvement, MassDOT will likely avoid losses considerably higher than this each year.

Statewide Example. During Superstorm Nemo in February, 2013, the MBTA made the pre-emptive decision to shut-down services for 48 hours. The MBTA also shut down its services between January 26 and January 28, 2015, during severe winter weather, and then provided partial service as it removed snow and made repairs to frozen lines. Service was not fully restored for a month. Losses due to disruption in service were estimated by IHS Global Insight to be \$265M for each 24 hour period (Section 7 and Appendix 3: <http://www.mass.gov/governor/docs/news/attachment-a-severe-winter-weather-pattern-impacts-supplemental-info.pdf>). In June 2015, Governor Baker announced an \$83.7M MBTA Winter Resilience Plan to add snow blowers and plows, upgrade third rail heaters, and acquire de-icing fluids (http://mbta.com/about_the_mbt/news_events/?id=6442454500&month=&year). This resiliency plan should help avoid shutting down the MBTA and avoid the loss of hundreds of millions of dollars during the next serious winter storm.

b.2 Total Necessary Investment in Resilience. The cost of proposed actions described for our Target Areas (Exhibit E) is under \$200M. This includes statewide tree planting and resilient energy and heat statewide, plus more intensive interventions in the MID-URN Target Areas where less than 3% of MA's population lives. The Commonwealth's largest infrastructure projects – the Boston Harbor cleanup and the Central Artery/Third Harbor Tunnel transportation project – cost \$6B and \$22B, respectively. Using these projects as guidance, a reasonable estimate of the general amount of total investment in resilience to appropriately

benefit MA, not just the MID-URN Target Areas, effectively now and into the future, is billions of dollars, depending upon the resilience strategies. However, these costs may be well-justified when comparing them to potential losses due to disasters under climate change. Even under current climatic conditions, impacts from extreme events are costly and impacts from climate change will be much higher. The average annual cost of climate change impacts to the U.S. could reach 2.6% of the gross domestic product by 2100 (Ackerman et al 2009.pdf), posing a challenge to MA and could place a disproportionate burden on vulnerable populations including low- and moderate-income areas such as our Target Areas, elders living on fixed incomes, and workers who cannot access alternative housing or transportation during disasters. All of this places the cost of necessary investment into perspective since the cost of inaction will likely be far higher.

b.3 Vulnerable Populations and Factors Hindering Resilience. Residents of our Target Areas live on limited incomes and struggle with more immediate other problems, leaving them with limited capacity to meet the challenges of climate change impacts and resiliency strategies. *Springfield* is a diverse city of 153,000 with people of color comprising 65% of the population, including 40.5% Hispanic or Latino, 19.2% Black or African American, 2.2% Asian and 2.0% two or more races. Median household income is \$34,311 and 29.4% of the population lives below the poverty level, these figures are considerably higher than the national median household income of \$53,046 and poverty rate of 15.4%. 64.1% of children under 18 years old live in households with Supplemental Security Income, cash public assistance income, or Food Stamp/SNAP benefits (<http://factfinder.census.gov>). Of those 25 years and older, 31.3% of the population has graduated from high school and 10.7% has earned a bachelor's degree (<http://factfinder.census.gov>). The Commonwealth has designated Springfield one of 26 "Gateway Cities," defined as having median household incomes below the state average, populations greater than 35,000 and less than 250,000, and rates of educational attainment of a bachelor's degree (or higher) that are below the state average. The City of Springfield was awarded \$21.8M CDBG-DR funds for disaster related relief, long-term recovery, restoration of infrastructure and housing and economic revitalization as a result of federally declared disasters in 2011

and 2012. Largest employers in Springfield are: Baystate Health, Massachusetts Mutual Life Insurance, Bank of America, Mercy Medical Center and Sisters of Providence Health System, Big Y Foods, Inc. (supermarket), Northeast Utilities, Springfield College, Western New England College, Solutia, Inc. (chemical merchant wholesaler) and the U.S. Postal Service.

The *Deerfield River Subwatershed Target Area* has several distressed characteristics. 51.23% of the residents in the Target Area earn less than 80% of AMI. In Shelburne, 130 of renters had income less than 50% of median and 65% had a severe housing problem between 2007-2011, paying more than half of their incomes on rent, or living in housing that was overcrowded, or without kitchen or plumbing based on ACS data provided by HUD. Between 2008 and 2012, these figures were 135 renters and 67% (see printout from HUD). Also, there is one brownfield each in Buckland and Colrain, and five in Greenfield (MassDEPBrownfields.pdf). The Target Area is predominantly white with median household incomes and poverty rates of \$49,760 and 9.4% in Buckland; \$50,329 and 12.1% in Charlemont; \$50,833 and 10.1% in Colrain; \$48,230 and 15.4% in Greenfield; \$63,750 and 13.6% in Hawley; \$53,750 and 9.8% in Heath; \$36,875 and 11.1% in Monroe; \$53,750 and 15.9% in Rowe; and \$55,500 and 7.3% in Shelburne. Greenfield's population of 17,526 is 67% of the Target Area's population. The other towns have populations between 117 and 2,093 (<http://factfinder.census.gov>). Districts of the Mohawk Trail Regional School System, serving Target Area communities Buckland, Charlemont, Colrain, Hawley, Heath, Rowe and Shelburne, "have a high rate of mobility for both foster children and families who struggle with housing" (<http://colrain-ma.gov/documents/TownReports/Colrain2013AnnualReport.pdf>). Largest employers in Charlemont are the whitewater rafting industry, Charlemont Inn, and Hawlemont Elementary School. State aid is the 2nd largest town revenue source, with commercial revenues accounting for less than 15% of the total revenue collected (<http://www.charlemont-ma.us/economic-development>). Charlemont has a very high share of mobile homes and trailers, making up 13% of the total housing units (<http://www.charlemont-ma.us/executive-summary>). Buckland is a predominately agricultural community. The Mohawk Trail Regional School System is a major employer in the area. The public schools and municipal services are the

largest employers in Rowe. The municipality is the largest employer in Monroe, Hawley and Heath

(http://lmi2.detma.org/lmi/Top_employer_list.asp?gstfips=25&areatype=05&gCountyCode=000198).

Construction and retail are also important employment industries. Manufacturers Mayhew Steel and the Lamson & Goodnow Cutlery Manufacturing Company are also large employers

(<http://town.buckland.ma.us/about-buckland/about-buckland.html>). In Greenfield, the largest industries are manufacturing, wholesale and retail trade, and health care. *Williamstown* has a population of 7,754, median household income of \$71,612, and poverty rate of 6.6%. Employers include Williams College and businesses related to tourism. Although Williamstown is not a low and moderate income community, 65.6% of the residents earn less than 80% of AMI in the census block where the Spruces Mobile Homes were located.

Throughout *Massachusetts*, poverty levels have increased steadily over the past few decades (http://www.massbudget.org/report_window.php?loc=From%20Poverty%20to%20Opportunity.html). 19% of the population in Hampden County is below the poverty level, as is 21% of Suffolk County, where Boston is located. The number of residents who are poor/near poor (incomes <200% of poverty level) has increased from 20-24% in over 25 years. The child poverty rate rose from 9% in 1970 to 16% in 2013. Children of color are at particular risk; almost ½ of Black and 2/3 of Hispanic children are poor. About 20% of families are headed by a single female; those families with at least one child age 3 years old or younger are more likely to be in low wage jobs. Residents are also burdened by high rent as a % of household income; in Hampden County, 45% of renters pay 35% or more of their household incomes on rent. The tourist-dependent areas of MA, where property values are high and wage low, are even harder hit by high rents: in Dukes County, that figure is 47% and in Barnstable County, a staggering 50%. All of these factors contribute significantly to the inability of vulnerable populations from achieving greater climate resilience.

b.4 Factors Contributing to or Hindering Disaster Recovery and Resilience In Target Area and Beyond.

Social, educational, environmental, economic, or governmental factors hindering disaster recovery and resilience in the MID-URN Target Areas are poor stormwater drainage and frequent flooding; frequent power outages; aged infrastructure; shortage of housing; and underutilized natural resources.

c. Appropriate Approaches/Best Actions

Plant More Trees. All of MA experienced a large amount of tree damage or loss resulting from the state's six qualifying disasters. The loss of tree canopy increased stormwater runoff and likely increased combined sewer overflow activations in Springfield while also increasing cooling and heating costs, and associated energy demands. Loss of trees in the Deerfield River Subwatershed also contributed to stormwater runoff in the Town of Greenfield. Additional trees, including those installed in stormwater tree boxes, will draw up more stormwater. This will lessen stormwater flooding, CSO activations, and pollution from these discharges. It will also protect against urban heat island effect and lower the costs of heating and cooling.

Provide Reliable Power and Heat. Power outages in the Target Areas and all of MA were caused by heavy winds or rainfall that snapped utility poles, detached power lines, and caused trees and debris to come in contact with electrical lines. Reliable electricity and heat, such as solar PV, renewable thermal, and storage, will ensure that Target Areas have uninterrupted service. Wood pellets as a local alternative to heating oil and propane will ensure a more reliable supply if oil deliveries are impeded by road damage due to storms.

Repair and Prevent Damage to Infrastructure. Damage from the disasters was especially destructive to public infrastructure. Continued loss of services from affected infrastructure presents a hardship to communities. An appropriate approach is to immediately repair and make more resilient the infrastructure unmet recovery needs identified while qualifying Target Areas – specifically Maple Brook Culvert and Sewer Interceptor in Greenfield (resiliency will be increased with the reduction of sanitary sewer overflows), Nash's Brook Bridge in Greenfield (to be elevated and moved upland, out of the water), and the culvert at Trout Brook and Route 2 in Charlemont (to be redesigned to accommodate larger flows). It is also appropriate to replace stream-crossings (culverts) that are most at risk of being overwhelmed by high flows.

Protect Nature's Original Green Infrastructure – Forests – and Develop a Forestry Economy. Forests draw up water and nutrients, providing a natural buffer against the effects of overland flow and non-point source pollution. To ensure that the forests of the Deerfield River Subwatershed Target Area provide resilience against flooding and water pollution, they need to be managed to promote age and species

diversity. Introduction of new markets for forestry products is appropriate. Thriving wood pellet and nanotechnology industries will create demand for forestry products. This would create jobs in forestry, manufacturing, pellet delivery, and pellet boiler installation, and create a local source of heating fuel.

Restore or Introduce Other Natural Systems (Green Infrastructure). An appropriate approach is to stabilize the bank at the Shelburne Falls Fire District along the North River and restore the streambed at Trout Brook culvert. It is appropriate to use green infrastructure, including logs placed instream to calm or redirect flows, in conjunction with redesigned culverts, in the rural riverine system to manage higher streamflows and protect against scouring and loss of riverbanks. In urban Springfield and Greenfield, it is appropriate to use rain gardens, tree plantings, tree box filters, and permeable pavement, to reduce stormwater runoff, CSO discharges, urban heat island effect, and heating and cooling costs associated with the loss of trees.

Protect Water and Wastewater Infrastructure Against Flooding. Water and wastewater infrastructure needs to be inspected and retrofitted with flood-proofing strategies, if not moved altogether. The Charlemont Municipal Complex, housing fire, police and highway departments, and Shelburne Falls Fire District's wells, well pump house and electrical system need to be moved upland, and out of the floodplain, if possible. It is also appropriate to floodproof the pump stations serving Springfield and Charlemont's wastewater plant.

Manage Combined Sewer Overflows. Stormwater runoff contributes to flooding and poses threats to water quality, aquatic health, and human health. Springfield has a combined stormwater and wastewater system, whereby raw wastewater, combined with stormwater, discharges to the Connecticut River during storm events. It is appropriate to design the wastewater system to provide relief to hydraulic choke-points so that more combined sewage can get to the treatment plant and to separate stormwater from the combined system.

Facilitate Replacement of Lost Housing. With the loss of the mobile homes at the 191 homes at the Spruces in Williamstown, an appropriate approach is to assist the town in preparing the site at 330 Cole Avenue for new affordable housing, including cleanup of the brownfield.